Read Nobelists of 1951

CHEMISTRY

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Science's Nobelity

IN THE SCIENTIFIC world no honor rates higher than a Nobel prize. Since they were first established in 1901 as a financial reverberation of the invention of dynamite by the Swedish chemist, Alfred Bernhard Nobel, the Nobel prizes in chemistry, physics and medicine have recognized, with extraordinary appreciation of the verdict of history, the great fundamental advances since the turn of the century. The list of Nobelists is itself a biographical outline of scientific history of the 20th Century.

One reason for this is that Nobel's original idea of the awards has been modified in one respect. It was his intention that the considerable sum of cash be given to a scientist who had made a great discovery the preceeding year. This was not so much to honor him as to give him the financial independence to continue with effective research and make new discoveries. The financial rewards in his day to the innovation in pure research were not so assured as they are now.

This short lapse between discovery and recognition did not prove practical. Usually a half dozen years or more elapse between the culmination of the achievement and the award. The chemistry award this year is for discoveries made as long as 11 years ago.

The Nobel prizes acquired their stature as science's most honored accolade largely because of the careful and successful judgment that was used in picking their recipients.

The selection of the Nobelists in chemistry and physics is the prerogative of the Swedish Royal Academy of Science, and the award in physiology and medicine is voted by the Caroline Medico-Chirurgical Institute in Stockholm.

The size of the cash bestowed gave them another kind of prestige. They are still the largest annual prizes in science. Usually more than $30,000 (this year $32,350), they far exceed the usual $1,000 awards that have multiplied so freely in recent years. Only occasional awards, such as the one of £100,000 given by Great Britain to Sir Frank Whittle for his jet engine, have exceeded the Nobel prize in monetary value. Such so-called prizes are few and infrequent. They are more in the nature of a purchase than an award.

In one sense, chemistry, for its own sake is its own reward. But it is also gratifying that our living great have the satisfaction of world acclaim from Nobel prizes and from other important recognitions which have grown with the importance of chemistry and its industrial and public appreciation.

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➤ DR. EDWIN M. McMILLAN *at the controls of the 300-million electron volt synchrotron at the University of California.*

Nobelists of 1951

➤ NEVER AGAIN in the history of science will it be possible to discover through their creation a half dozen major chemical elements as well as over 100 isotopes or varieties of other chemical elements.

This is the imposing record of the two scientists of University of California's Radiation Laboratory who have been awarded this year's Nobel Prize in Chemistry.

These two scientists have between them shared in the discovery of elements 93, 94, 95, 96, 97 and 98, the most important of which is plutonium number 94. They are Dr. Glenn T. Seaborg, professor of chemistry, and Dr. Edwin M. McMillan, professor of physics.

Before the dawn of the transuranium era of science, for which Seaborg and McMillan are largely responsible, there were only 92 elements known. The heaviest of them was uranium. This is the essential material for atomic bombs because the modern A-bomb's plutonium is made from it.

In 1940 McMillan with P. H. Abelson discovered neptunium, element 93, and then Seaborg with associates carried out extensive researches which resulted, also in 1940, in the discovery of the new element plutonium, element 94.

A year earlier German experiments had shown that bombardments of uranium with slow neutron atomic

➤ Dr. Glenn T. Seaborg *in his laboratory at the University of California, where the newest elements were discovered.*

particles split the atoms and converted mass into energy. This was the famous fission process of nuclear energy basic to the atomic bomb.

One variety of plutonium, the 239 isotope, was identified as being fissionable like the 235 isotope of uranium. Although only microscopic amounts of this plutonium were created in the University of California 60-inch cyclotron, it became an alternate material to the rare natural isotope of uranium, U-235, as the material of the projected atomic bomb.

Transuraniam Chemists

Seaborg headed an intensive top-secret wartime project to study and produce plutonium, working with a large staff at the Metallurgical Laboratory in Chicago. So successful was the project that although the full scale plutonium effort did not begin until 1942, a plutonium bomb was dropped in actual warfare in 1945.

Seaborg and his associates discovered two other elements, number 95 or americium, and number 96, curium, during the war period. In postwar research, element 97, berkelium, and element 98, californium, were added to the periodic table, both created in the 60-inch cyclotron.

After his work on neptunium, McMillan worked on the early stages of radar and sonar devices for the war. In 1942 he went to Los Alamos to participate in the development of the atomic bomb. McMillan developed the theory of the synchrotron type of atom smasher which carried on the cyclotron pioneering which won for the University of California's Dr. Ernest O. Lawrence the Nobel prize.

McMillan's synchrotron principle locks the atomic particles in the atom-smashers in such a way that under electromagnetic influence they are coaxed to higher and higher energies. It is applied to the giant accelerators now being built, some of which will rival nature's cosmic ray power.

This idea of McMillan's was independently discovered by a Russian physicist, V. Veksler, but since his publication in 1945 no word of any practical use in Russia has come through the iron curtain.

The Radiation Laboratory at Berkeley is still producing results, but many of them are being accumulated in secret files deemed to be of prime military importance.

The discovery of neptunium has an interesting history, which begins with experiments performed in 1934 by Enrico Fermi, the great Italian physicist now at the University of Chicago. At that time uranium, element 92, was the heaviest known element. Fermi believed that if he added a neutron to a uranium atom, that atom would transform itself into uranium-239, a highly radioactive species of uranium with a very short half-life; and that U-239 shortly would then transform itself into an entirely different kind of atom which would be element 93. Of course, element 93 was not known to exist in Nature. But since 1934, when artificial radioactivity was discovered, many synthetic isotopes of elements had been made by transmutation.

Now, if element 93 were made by

this process, proof would have to be found that it was actually element 93 and not something else. The first step, in getting proof is to separate the new substance from the target materials in which it is made—in this case element 93 from uranium. This is done by what is called a carrier. The carrier is chosen from among the chemical relatives of the new element.

Properties Predicted

Before a carrier is chosen, the scientist predicts the new element's chemical properties. This can be done by means of the periodic table, in which elements having related chemical characteristics appear at periodic intervals. Thus it appeared to all scientists, including Fermi, that element 93, if it could be made, would be a relative of a family of elements including manganese and rhenium. Therefore, the conventional way of separating the new element would be to choose one of these relatives, mix it with the bombarded target material, and then subject the mixture to chemical reactions that would separate the relative from the mixture. The new element, because of its familiar chemical characteristics, would be expected to come out with the relative. The relative is called a "carrier." The carrier is nonradioactive, of course; therefore, when radioactivity appears in the carrier the scientist knows that he has separated some transmuted body out of the target material.

Fermi chose as his carrier a manganese salt. In this carrier he found several different patterns of radioactivity. Thus there were a number of products of the uranium bombardment that did not behave chemically like uranium and therefore must be something else. This was one indication that element 93 had been created.

A second major piece of evidence in demonstrating the existence of a new radioactive element is to show that it has a pattern of radioactivity different from any other element. Each radioactive isotope of each element has a characteristic half-life, and this is like a fingerprint.

Therefore, once Fermi had separated the transmutation product, he set about to determine half-life. But instead of one substance with a single radioactive pattern, he found several with different patterns. He felt that one of these was U-239 and one of the others was element 93.

Other researchers took up these experiments. Among these were Otto Hahn and Lise Meitner in Germany. In uranium bombarded with neutrons were found bodies with many types of radioactivity. Soon scientists believed that they had created synthetic elements up to and including element 97.

But as the scientists studied the new atoms they had created, doubt began to grow that they were actually elements heavier than uranium. When examined in detail, the chemical behavior of these atoms indicated that they could not be transuranium elements.

Fission Products

In early 1939 Hahn, Strassman, and Meitner reported their now-famous conclusion that these bombardments with neutrons actually were splitting uranium atoms into two approximately equal pieces. This was atomic fission, the mechanism of

nuclear energy release used today in the atomic bomb. The radioactive atoms once thought to be transuranium elements were actually fragments of this fission. These fission fragments proved to be isotopes of elements in the middle of the periodic table, such as barium, krypton, etc. Today these fission products are separated in the Oak Ridge piles, and sent to scientists who use them in "tracer" experiments of all kinds.

New Phenomenon

Immediately after Hahn, Strassmann, and Meitner made their announcement, physicists all over the world began studying the new phenomenon. Several studies were undertaken with the 60-inch cyclotron in the Radiation Laboratory at the University of California, a machine that had just been completed.

McMillan was one of the Berkeley experimenters. He undertook to determine the range of the fission products; that is, just how far they travel from the point at which fission occurred. He did this with a target made of sheets of aluminum foil. On one sheet he smeared a little uranium oxide. Over the uranium he placed several more sheets. This target was placed in the neutron beam. When a uranium atom fissioned, the energy released drove the fission products with great force into the aluminum foil. The number of sheets the fragments penetrated determined their range, which turned out to be the equivalent of 2.3 centimeters in air.

In complementary experiment, McMillan smeared a cigarette paper with uranium oxide and then placed several other cigarette papers on top of the uranium. When fission occurred in the uranium target, the fragments were driven into the overlying cigarette papers. McMillan then analyzed with radioactivity counters the different papers to determine in which ones the fission fragments came to rest.

In the course of the latter experiment, McMillan examined the paper on which the target uranium had been smeared. In this target material he found a very peculiar thing; a source of radioactivity that was distinct from the target uranium itself. Now, it was not reasonable to suppose that a fission product caused this radioactivity. The fission products had been propelled out of the target uranium and were stuck in the overlying cigarette papers. This radioactivity must come from some previously unknown body. So McMillan sent the target material to a colleague to see if the new substance behaved like rhenium and therefore might be element 93. He reported that the substance behaved like the rare earth elements at the middle of the periodic table, and therefore it appeared to be a fission product.

Element 93

Despite these findings, McMillan harbored at the back of his mind a belief that this was element 93. The biggest piece of evidenec at this point was the fact that the substance did not hop out of the target material along with the fission products. Rather, it stayed in the target. This would be expected of atoms that were transmuted rather than fissioned. Fission fragments would almost have to be expelled from the target by the gigantic energy released in the splitting of the uranium atom. Therefore,

McMillan felt the strange new substance must be something other than a fission product, probably element 93.

A year later, early in 1940, McMillan took up the experiment again. While McMillan was working on the problem, P. H. Abelson, then at the Carnegie Institution in Washington, D.C., came to Berkeley on vacation. Abelson joined McMillan on the problem.

They conceived the possibility that element 93 might not actually be a relative of rhenium. Perhaps there was a deviation in the periodic table, similar to deviations that appeared elsewhere. Perhaps the reason their new substance was "carried" with rare earth elements was because it was in fact closely related to uranium, rather than rhenium, and under some conditions similar to the rare earths.

Like a Rare Earth

Working on this premise and using cerium, a rare earth, as a carrier, McMillan and Abelson quickly separated their new substance from the uranium target. They verified that it had a distinctive half-life of 2.3 days and that it had chemical properties resembling those of uranium but actually distinct from any other element known, (under certain circumstances uranium can behave like a rare earth element). They therefore concluded that this was indeed element 93. McMillan named it neptunium in analogy to the naming of uranium which was named after the planet. Neptune is the planet immediately beyond Uranus in distance from the earth.

McMillan next started experiments directed at finding element 94. He felt it should be possible to transmute uranium into element 94 as well as 93. This time he used, instead of neutrons, deuterons (heavy hydrogen nuclei) from the 60-inch cyclotron. He found what appeared to be a distinct new pattern of radioactivity. However, before he could definitely identify this as element 94, McMillan was called to war work at Massachusetts Institute of Technology. He turned over to Dr. Glenn T. Seaborg all of his findings.

Element 94

At this point Dr. Glenn T. Seaborg, Joseph W. Kennedy and A. C. Wahl, took the experiment. In a series of experiments they demonstrated that it was indeed element 94, that it was, like uranium, fissionable. They named it plutonium, and it is the important fissionable material used in atomic bombs. The chief purpose of the development of reactors was to make plutonium, and the multi-million dollar reactor plants at Hanford were put up to do the job on an industrial scale.

The significance of this contribution was very great. The discovery of neptunium solved a riddle that had baffled the world's greatest physicists and showed that transuranium elements could be made. It led immediately to the discovery of plutonium, which multiplied manifold the world's supplies of fissionable materials. These discoveries have had, and will continue to have, an important influence on the course of human events.

In 1934 Seaborg had received his A.B. from UCLA and transferred to the University of California, Ber-

keley. There in 1937 he earned his Ph.D., his thesis subject concerning the inelastic scattering of fast neutrons. The following two years Seaborg was laboratory assistant to the late great Dr. Gilbert Newton Lewis, then Dean of the College of Chemistry on the Berkeley campus. They published several scientific papers jointly. Seaborg, a great admirer of Dr. Lewis, profited greatly from this association with one of the greatest scientific geniuses of our time.

Seaborg's Work

In 1939 Seaborg received his appointment from the University of California, as an instructor, and in 1941 he was promoted to the rank of assistant professor. During this period Seaborg and his associates discovered several dozen isotopes and published some forty scientific papers. The fruit of their labors, however, culminated in the discovery (1940) of a new element—plutonium—(element 94)—which was to become the first synthetic element ever to be seen. The importance of plutonium became apparent when it was found that one of the isotopes of the element was fissionable. This meant that it could be used as a source of atomic power, although plutonium would have to be produced in sufficient quantity and the chemists would have to learn the chemistry of the new element and learn how to separate it from uranium and the fission products. He and his group were also responsible for the discovery of the other atomic energy isotope, U-233, which is formed from the action of neutrons on thorium and which has opened the possibility for the indirect use of thorium in atomic power. They also found the existence of small amounts of plutonium in nature in such ores as pitchblende and carnotite.

Heads of the Manhattan Project decided the plutonium work should be undertaken at the University of Chicago Metallurgical Laboratory; so Seaborg secured a leave of absence from the University of California to go to Chicago in April, 1942.

Seaborg remained at the Metallurgical Laboratory from April, 1942, to May, 1946, as chief of the section working on the transuranium elements. Here one of his main responsibilities was the working out of the complete chemical process for the separation at Oak Ridge, Tenn., and Hanford, Washington of the plutonium from the mixture of uranium and intensely radioactive fission products.

Seaborg was chosen for this assignment on the basis of the reputation he had established even before the war at the University of California as one of the leading workers in radiochemistry and in the investigation of new radioactive isotopes.

Plutonium Project

When the government called him to Chicago to lead the chemical project on plutonium, Seaborg brought with him a group of even younger University of California associates who had been co-workers in nuclear chemistry on the Berkeley campus. They formed the nucleus of the great plutonium team as it expanded to 100 plus scientists under Professor Seaborg's supervision.

As late as 1942 it was estimated by some very responsible scientists that it would not be possible to learn enough about the chemistry of plu-

tonium to design a process in less than five years, but the process was designed and actually put into operation to such an extent that it was possible to produce atomic bombs from plutonium in a little over three years from the time Seaborg first came to Chicago.

The success of the work was due to Seaborg's ability as a scientist, coupled with his very unique ability as a designer and a director of work. He was outstanding among his colleagues as a man who was able to direct his efforts toward the important goal and avoid any waste of the limited manpower on side issues. As a director he showed a great deal of imagination and daring in embarking on a program of ultramicrochemical research, working with quantities of a thousand-fold smaller than those which had been considered standard microchemical quantities before. It was only by using these novel and unusual techniques that it was possible to make some of the essential chemical tests on plutonium at a time when only microgram quantities were available.

Elements 95 and 96

During his stay at the Metallurgical Laboratory Seaborg and his associates also discovered two more transuranium elements. Element 95, americium, was discovered during late 1944 and early 1945, and element 96, curium, during the summer of 1944.

While he was still on leave from the University of California, the Berkeley university promoted Seaborg from the rank of assistant professor to that of a full professor (1945)—skipping the rank of associate professor. In May, 1946, Seaborg returned to the University of California to assume his position in the Chemistry Department and to take responsibility for the direction of the chemical research in the Radiation Laboratory of the university.

He is at present engaged in research work at Berkeley on the transuranium elements and on the identification of various nuclear reactions induced as a result of the operation of the Berkeley 184-inch cyclotron. He is also directing the work of a group of graduate students in the field of nuclear chemistry as well as teaching a lecture course in this field.

In this postwar research Dr. Seaborg and his colleagues have discovered element 97, berkelium, and element 98, californium. Both were created with the 60-inch cyclotron.

Spallation

He and his colleagues also have discovered a new phenomenon of high energy bombardment, called "spallation." Ultra-high energy particles from the giant cyclotron knock up to 40 or more particles out of heavy nuclei. A study of the nuclear debris of these bombardments has revealed the presence of radioactive isotopes of common elements that cannot be made in any other way.

One of his more important contributions to science was his recognition that the heavy elements form a transition series of "actinide" elements in a manner analogous to the rare earth series of "lanthanide" elements.

His publications now stand at about 120 and include the compilation of complete tables of isotopes as well as review articles on artificial radioactivity and the applications of tracers to chemistry as well as a large

number of papers on artificial radioactivity and problems in nuclear physics and chemistry.

A large new body of knowledge has evolved from Seaborg's laboratory. For any one of a number of discoveries he has made or in which he has been the leader, Seaborg would have won a significant place in the annals of science. However, so thoroughly has he exploited and unified a new area of human knowledge that he has set himself apart as one of the great pioneers of science.

Contributions

The following are a few of his contributions and their significance:

1. *Nuclear Fuels.* After clearly demonstrating the existence of element 94 (Pu 238), Seaborg and his colleagues succeeded in preparing and identifying plutonium 239 and determining that, like U-235, this isotope fissions with slow neutrons. This discovery was immediately significant because it provided an alternate and easier method of obtaining fissionable material from Nature. Following this discovery reactors were built for the conversion of U-238 into plutonium, which can be more easily separated from uranium metal than U-235. This multiplied manifold the world's potential of nuclear fuel.

The discovery by Seaborg and his group of U-233 further increased the nuclear fuel potential. This synthetic isotope of uranium was made from thorium, much as plutonium was made from uranium. Thus thorium was added to the nuclear fuel stockpile.

While methodology will be referred to later, it is desirable here to point out that Seaborg's laboratory carried the plutonium discovery to a stage of practical application. Seaborg and his colleagues were forced to work with plutonium in quantities measured in millionths of an ounce, far too little to be visible. Such small quantities had not been used before to get the kind of chemical information needed by the Manhattan District. Yet Seaborg and his colleagues devised the techniques necessary to determine the basic chemical properties of plutonium. These studies, followed up in greater detail later, were the foundation of the successful separation and purification of plutonium on an industrial scale.

2. *New elements.* Plutonium was but the first of five new elements discovered by Seaborg and his group. The others are element 95 (americium); element 96 (curium), element 97 (berkelium); and element 98 (californium). In many cases a number of isotopes of these elements were found. Not only were the discoveries made, but the chemical properties of these elements were also elucidated in great detail, largely by the new techniques Seaborg and his colleagues developed. So thorough have these studies been that more is known about the chemistry of some of these synthetic elements than about many common elements that occur in nature.

3. *Actinide concept.* This is an esoteric chemical concept, but it is of utmost importance in assessing Seaborg's work. He demonstrated that the heavy elements form a "transition" series of actinide elements in a manner analogous to the rare earth series of the lanthanide elements.

This concept demonstrated for the first time how the heavy elements fit into the periodic table and therefore their relationships to the other elements. It enabled Seaborg to predict very precisely the chemical nature of transuranium elements from element 95 through element 118, and to extend the periodic table through element 98. In that it systematizes and unifies the momentous individual discoveries of this laboratory and contributes to our larger understanding of Nature, this concept lends to Seaborg's work a distinction that is achieved rarely in science.

4. *Discovery of isotopes.* Seaborg and his colleagues are responsible for the identification and determination of the nuclear properties of more than 100 isotopes of elements throughout the periodic table, in addition to the discovery of five of the six transuranium elements.

5. *Prediction of isotope properties.* The great body of information assembled in Seaborg's laboratory makes it possible to predict the radioactive characteristics of many isotopes of elements still to be identified.

6. *Methodology and instrumentation.* Under Seaborg's leadership whole new bodies of methodology and instrumentation have been pioneered. Without these developments, many of the new discoveries could not have been made. Indeed, these practices are a cornerstone of modern nuclear chemistry, and the influence of Seaborg's laboratory is felt wherever research in nuclear chemistry is being done.

The following are some of the high points of this technical progress:

The techniques for the separation of minute quantities of materials from chemical mixtures have been greatly improved.

Radiation detection and measuring instruments and methods have been refined. The greater efficiency and accuracy in measuring alpha particle energies, for example, permits scientists to chart the properties of the heavy elements.

Ultramicrochemistry

Ultramicrochemical techniques were adapted to nuclear chemistry in Seaborg's laboratory. This was of greatest importance in the development of the separation process for plutonium, and later played a big part in subsequent discoveries. A whole system of new tools, designed for physical chemistry on a scale never before attempted, was evolved.

A whole methodology for the use of high energy accelerators and nuclear reactors in causing transmutations came out of Seaborg's laboratory. New knowledge and understanding of nuclear reactions evolved in the course of the laboratory's work made it possible to predict what bombardments must be made in order to achieve a desired transmutation. This understanding is responsible in no small measure for the new discoveries that have been made, and contributes significantly to our general understanding of nuclear reactions.

In addition to his work with Seaborg on neptunium, Dr. Edwin M. McMillan is honored for his theory of phase stability. This has shown physicists how they can extend the energy range of high energy particle

accelerators ("atom-smashers") far beyond that of the machines of the 1930's.

In pre-World War II cyclotrons an effort was made to make particles meet fixed conditions established in the machines. This worked out very well in the relatively low energy machines of the 1930's. However, it was clear that once the particles reached an energy of about 100 million electron volts (MEV), they could not be accelerated any further under the fixed conditions established for low energy acceleration.

Higher Energy

McMillan has shown how the conditions, not just in cyclotrons, but in many types of accelerators, can be adjusted as particles are driven to higher energy. Thus the conditions in the machine are accommodated to suit the particles. This makes it possible to give particles an almost indefinite number of pushes in an accelerator, and to drive them to energies that seem at present limited only by the capacity of the equipment. The bevatron, an atom-smasher now being built at the University of California Radiation Laboratory, on the basis of McMillan's theory, is designed to accelerate protons to 6.4 billion electron volts—more than 60 times the highest energy that could be hoped for with the cyclotron design of the 1930's.

The principle applies to "atom-smashers" that accelerate particles in circular or spiral orbits. Such an atom-smasher consists of a vacuum chamber housing an accelerating apparatus, all of which is placed in a magnetic field. The vacuum permits charged atomic particles to move freely in the chamber. The accelerating apparatus imparts pushes to the particles. The magnetic field makes the particles travel in a circle.

In cyclotrons of pre-World War II design the particles would tend to fall out of step with the pushes applied.

McMillan showed how particles can be "locked" in orbits in accelerators and maintained in these orbits by the manipulation of the magnetic field or the frequency of the electrical impulses, or both. Continued manipulation of the magnetic field, the electrical impulses, or both, keeps them in step with the electrical pushes, and they can be thus coaxed to higher and higher energy.

Synchronization

The synchronization of particles with the operation of the machine helped to name the new machines. Thus there are electron synchrotrons and proton synchrotrons. Cyclotrons based on phase stability are called synchrocyclotrons. Other names, such as bevatron and cosmotron are also in use. Most post-war high energy accelerators are based upon phase stability.

McMillan has put his ideas into practical effect and demonstrated their feasibility. With Manhattan District support, he started an electron synchrotron in October, 1945. This was completed in 1948, and operates successfully at an energy of 322 MEV. Meanwhile smaller machines had been built in England and by the General Electric company in this country. A number of machines of design and energy range similar to McMillan's are now operating in the United States.

Earlier, in 1946, the 184-inch Berkeley cyclotron, originally designed along lines of pre-war machines but redesigned to employ phase stability, went into operation. It had been hoped that 100 MEV might be reached after an initial start at about 50 MEV. With the new design it operated easily at 200 MEV for deuterons (nuclei of heavy hydrogen). A number of other synchrocyclotrons, of similar design and comparable energy range, have been built elsewhere.

McMillan's concept has showed physicists also how they may build machines to accelerate heavy particles into the energy range of billions of electron volts. At Berkeley, the Bevatron, a $9 million machine designed to accelerate protons to 6.4 billion electron volts, is now under construction, with funds supplied by the AEC. At the Brookhaven National Laboratory, the Cosmotron is being built to reach 2.5 BEV with protons. In England a similar machine is designed to achieve 1.3 BEV.

In the Bevatron protons will travel more than 300,000 miles, a distance greater than that from the earth to the moon! This trip will be taken in 1.85 seconds, and the particles will emerge at about 184,000 miles per second, 99 per cent of the speed of light. During this trip the protons will vary not more than a few inches from a strictly prescribed path. Such is the power that the theory of phase stability has bestowed upon physicists.

McMillan's theory has made it possible for physicists for the first time to create man-made cosmic rays, for study under controlled conditions in the laboratory. With the 184-inch cyclotron mesons were first made in the laboratory. These are low energy cosmic rays, but cosmic rays nevertheless. And this feat has been duplicated by other synchrocyclotrons and by McMillan's and other synchrotrons. Moreover, with these machines, it has been possible to study and understand other high energy nuclear reactions that were previously beyond reach.

With the billion volt machines it will be possible to penetrate a new frontier of physics. It should be possible to create heavy particles, perhaps the long-sought negative proton, to cause multiple meson production, and to study in the laboratory a general new region of high energy nuclear reactions.

Two Heaviest Atoms Manufactured

➤ THE TWO heaviest atoms ever known to exist have been manufactured in the Radiation Laboratory of the University of California at Berkeley. They are berkelium 245 and californium 246. The new berkelium isotope has a half life of about five days. The new californium isotope has a half life of 35 hours. These two new isotopes are reported by Drs. E. K. Hulet, S. G. Thompson, A. Ghiorso and K. Street, Jr.

➤ Dr. Ernest T. S. Walton *of Trinity College, Dublin, Ireland, shares with Cockcroft the Nobel Physics prize.*

➤ Sir John D. Cockcroft, *director of England's Atomic Energy Establishment.*

Subatomic Physicists

➤ Atomic transmutations, commonplace now, had their beginnings more than a decade before the first atom bomb was set off. Key roles in this early work which ushered in the Atomic Age were played by the two British scientists who share the 1951 Nobel Prize in physics.

They are Sir John D. Cockcroft, since 1946 director of England's Atomic Energy Establishment, and Dr. Ernest T. S. Walton, now at Trinity College, Dublin, Ireland.

In 1932, these two collaborated, at Cambridge University's famous Cavendish Laboratory, in producing the first successful high-voltage atom-smashing machine. Their feat was the more remarkable because of the relatively low voltage used, about 600,000 volts compared to billion-volt ranges now used.

With this 600,000-volt potential, they shot swiftly moving protons, hearts of the hydrogen atom, at a lithium target. A lithium atom, that was struck by a fast proton, captured the hydrogen particle, then split into two alpha particles, which are the hearts of helium atoms. A large amount of mass was thus transformed into energy, and, on a much more vast scale, this is what happens when an atomic bomb explodes.

The energy given off by the capture-and-splitting process was several hundred times as much as that possessed by the proton whose smashing brought about the reaction. But still, for every atom disintegrated, several millions of particles were required.

Some 25 times the number of helium atomic hearts were shot off from boron when this element was attacked by a stream of protons using the same technique that the two scientists had successfully applied to transmuting lithium into helium with release of energy.

By bombardment with hydrogen, also, fluorine was broken up into oxygen and helium, and beryllium was changed into lithium and helium.

Chemical Exposition Opens

➤ THE BIENNIAL Chemical Exposition opening in New York City marked the last week of November.

Exhibit material at the Exposition includes a great variety of raw, partially manufactured and finished chemical materials and materials of construction; it includes equipment for conducting chemical processes and the mechanical preparation of raw materials for all sorts of manufacturing plants. Every phase of chemical industry is covered, from the equipment of the laboratory with its elaborate paraphernalia for conducting analyses and measurements, through the intermediate pilot plant where actual manufacture is conducted on a small experimental scale, to the fully developed industrial unit and finally the complete chemical manufacturing plant. A significant fact is that much of the specialized equipment shown for various processing steps is of universal industrial interest.

Substitutes for War-scarce Materials

➤ CHEMISTRY is providing substitutes for some of the war-scarce materials that are creating industrial shortages.

More than two million pounds of metallic copper annually are being saved by the substitution of organic chemical compounds, the dithiocarbamates, for copper used as an insecticide in orchards, Dr. John C. Dunegan of the U. S. Department of Agriculture at Beltsville, Md., told the Twelfth International Congress of Pure and Applied Chemistry. The same chemicals are also saving four to seven pounds of sulfur for every 100 gallons of insecticidal spray.

One of the oldest minerals known, gypsum or alabaster, used for making plaster from the days of the ancients, is now yielding sulfur in countries that do not have resources of elemental sulfur or pyrites, Dr. G. I. Higson of Imperial Chemical Industries, Ltd., of Durham, England, told the chemists. Calcium sulfate in these deposits is being turned into sulfuric acid and ammonium sulfate for fertilizer use in several European factories and one plant in India.

Yellow Fever Conqueror

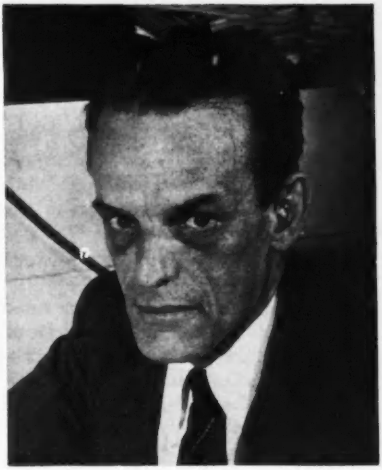
➤ AMERICAN SOLDIERS, sailors and marines of World War II as well as countless millions of men, women and children living in South America and Africa can cheer the award of the Nobel Prize for Medicine this year to Dr. Max Theiler of the Rockefeller Foundation, New York.

For it was Dr. Theiler's research of nearly two decades ago that produced a successful vaccine against yellow fever, once a world-wide scourge and until 1932 a constant danger to persons visiting, living or fighting in tropical regions of those continents.

Among vaccinated American servicemen stationed in Africa and South America, not one known case of yellow fever was reported, thanks to Dr. Theiler.

When Walter Reed, American Army officer, assisted by brave volunteers, proved the role of the mosquito in carrying the disease, it seemed as if the conquest of yellow fever had been made. But it had only begun. Yellow fever was cleaned out of the United States and some other regions by warfare against the stegomyia mosquito that carries it. For another 30 years, it took its deadly toll in other parts of the world and among the scientists who battled to conquer it.

Until Dr. Theiler's discovery, it had never been possible to give yellow fever to mice, only to monkeys. Efforts to get a strain of the yellow fever virus from monkeys for vaccinating humans were unsuccessful.



➤ DR. MAX THEILER *of the Rockefeller Foundation has been awarded the 1951 Nobel Prize for Medicine for his part in making yellow fever an almost extinct disease.*

Dr. Theiler, then an assistant and later instructor at Harvard Medical School, found that when he injected an irritating substance in the brain of a mouse at the same time that he injected the yellow fever virus, he could produce the disease in the mouse. Passing the mouse virus along from one mouse to another weakened the virus enough so that when given with blood serum from a recovered yellow fever patient, it could safely and effectively be used to vaccinate humans.

Later, Dr. Theiler and associates found a way to make the yellow fever virus grow in chick embryos and for some years this has been the source of material for the vaccine now used in the United States.

Zirconium New Poison Ivy Remedy

➤ A NEW and speedy remedy for poison ivy has been found in zirconium, the metal used to build atom bomb furnaces among other industrial uses.

The zirconium is used in a vanishing cream type of ointment. When tried on 47 patients, the itching and burning stopped and the rash began to get better with blisters drying up within 24 hours in 39 patients.

These good results were reported by Drs. A. Arnold Cronk and Dorothy E. Naumann of the Student Health Service at Syracuse University in the *Journal of Laboratory and Clinical Medicine.*

There is even some suggestion that the ointment might be a preventive. Before it was used on patients, it was tried on two volunteers, a girl and a woman who had previously had several attacks of poison ivy. A poison ivy extract was dropped on three places on the forearm of each volunteer. As soon as this had dried, the zirconium ointment was put on one of the three places while the other two on each arm were left untreated. Typical bumps and blisters appeared on the untreated spots but none on the treated ones.

The idea for using zirconium came from Dr. E. Wainger of the Titanium Alloy Corporation. He knew that the metal can combine with other substances in a way that makes possible their neutralization as poisons. This property makes it a potential antidote for plutonium poisoning. He found that when he added zirconium salts to urishiol, the poison of poison ivy, an inactive precipitate was formed. Fluid filtered from this did not cause ivy poisoning symptoms when tested on susceptible volunteers.

So far as is known, zirconium itself is not poisonous. The patients treated by the Syracuse doctors did not show any signs of poisoning or harm from the zirconium.

The zirconium ointment is made from zirconium oxide, stearic acid, potassium hydroxide, glycerine, water and carbon dioxide.

Cement Blocks Used for Yeast Spores

➤ BETTER and more efficient production of yeast spores—for beer and bread—can be secured by using concrete blocks for the growing of the spores instead of the usual gypsum blocks. The spores are grown in the pores of the blocks.

Gypsum blocks, according to V. Hartelius and E. Ditlevsen of the Carlsberg Laboratorium, Copenhagen, Denmark, often become infected on repeated use with bacteria and cannot withstand the heat necessary to sterilize them. The cement blocks prepared by the two scientists not only withstand sterilization heat, but also give somewhat better spore formation. The scientists reported their findings in the British journal, *Nature.*

Concrete Made Now With Corncobs or Air

Lighter Concrete for the Farm

➤ FARMERS who want a lightweight concrete for farm buildings can now utilize in making it either one of two plentiful farm materials—corncobs or air.

Both types of concrete are being made, the U. S. Department of Agriculture reports, but much work must be done before they are ready for general use. The first uses corncob pellets as filler or aggregate, the second is filled with bubbles of air.

The corncob concrete is being developed at the Michigan State College, East Lansing, in cooperation with the federal department. The pellets used are about three-eights of an inch in diameter and replace ordinary aggregate. Before mixing with the cement, water and sand, the corncob pellets are soaked in water for hours. Otherwise they will absorb the water in the mix and cause the concrete to rupture in setting.

An improved air-containing concrete, suitable for farm use, has been developed by the National Bureau of Standards. Officially it is called air-gravel concrete. Gravel is used as the aggregate, but air replaces all or part of the sand. The air bubbles are created in the mix by the use of chemicals called air-entraining agents. They make the mixture workable and give to the set concrete lightness and high insulating properties, because of the millions of tiny air cells it contains.

This air-gravel concrete was developed by R. C. Valore, Jr., and W. C. Green of the Bureau staff. It is particularly suitable for use in farm buildings because of its light weight, its high insulating properties and its resistance to water penetration.

Concrete normally contains a coarse aggregate such as gravel or crushed stone held together by a binder of mortar consisting of sand and cement-water paste. In the air-gravel concrete the sand is replaced by air bubbles, which act as a "lubricant" and produce a very workable mixture. The high-air-content concrete is made in conventional equipment but an aerating agent is added to cause it to foam and produce tiny spaces for air cells.

Mixtures made and studied at the Bureau consisted of high-early-strength portland cement, siliceous pea gravel, water, and one of two different air-entraining agents. These were a proprietary neutralized resin and a sodium-lauryl-sulfite-type detergent. Air content as high as 45% was found possible in concretes containing no sand, while there appeared to be a "ceiling" of about 30% in the air content of mixtures containing both sand and gravel.

The air-gravel concretes developed at the Bureau of Standards are considered experimental at the present time. The advantages of reduced weight and improved heat conductivity are partly offset by a loss of strength.

Metallic Crystal Is Grown, Watched Under Deformation

What Is A Metal?

by Robert Maddin
Assistant Professor of Metallurgy, The Johns Hopkins University

This account of new work on the structure of metals is reprinted with permission from the Johns Hopkins Magazine. The illustrations are by the author.

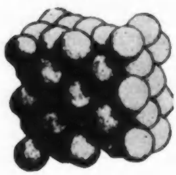
➤ To THE average man on the street, a metal is a smooth, hard substance whose properties are permanent except for occasional corrosion or deformation to a different shape.

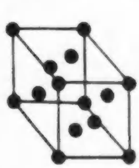
Closer examination, however, reveals a granular structure. In it individual grains can vary in size six orders of magnitude. A still closer examination, with the aid of x-rays, brings to light an orderly array of atoms within each grain.

Careful study has shown that in general, the atoms of metals are aligned periodically in three mutually perpendicular directions—much the same as if cork balls were to be packed close to one another and stacked in the hollows made by the close packing. The regularity of the atomic stacking, however, is not perfect; many positions are not filled, many atoms are not in their right places. These errors in stacking are termed imperfections, and it is thought that because of them, metals vary in behavior with respect to certain properties such as mechanical behavior and diffusivity.

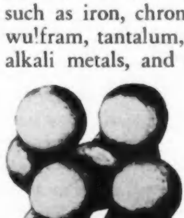
Since the atoms are in constant motion, these imperfections are constantly being healed; at the same time, new imperfections are being formed. Diffusion processes are continually going on. Instead of conforming to the usual static conception customarily held for a solid, there is something nearly as dynamic as a liquid.

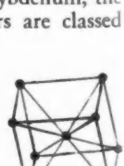
There are, in general, three ways in which the atoms of metals are packed in the solid state. Metals such as copper, aluminum, nickel, lead, gold, silver, palladium, platinum, and others are classed as "face centered cubic" (close-packed cubic) metals. In this crystal structure, as seen here,





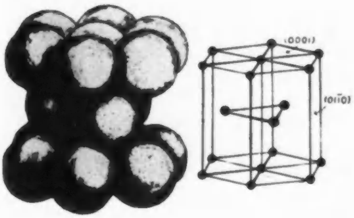
there is an atom at each corner of the cube and one on each face. Metals such as iron, chromium, columbium, wulfram, tantalum, molybdenum, the alkali metals, and others are classed





as "body centered cubic"; in this ar-

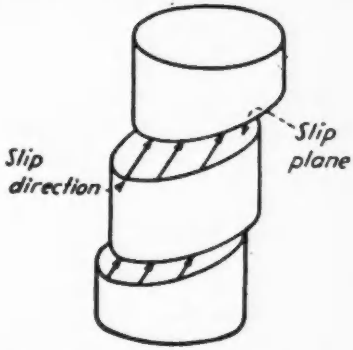
rangement, there is an atom at each corner and one in the center of the cube. Metals such as zinc, beryllium, cobalt, magnesium, titanium, and zirconium fall into the "hexagonal close packed" arrangement, illustrated thus:



Here, there is an atom at each of the corners of a hexagon and one at the center; the atoms above and below are nestled into the hollows made by those in the hexagon, so that every alternate atom is in an identical position one layer removed.

The atoms within any one of the grains referred to earlier are, in general, arranged in one of these three arrays; however, the orientation of one grain with respect to some arbitrary reference frame and its neighbor differs. Consequently, the grains do not fit together perfectly, and the result is a boundary region or grain boundary.

When metals are subjected to stresses in the plastic region (that region where the strains are permanent), each of the grains deforms by a translation or gliding of one part of the grain over another. This gliding or slipping continues within the grain until it meets an obstruction such as a boundary. Gliding occurs on planes of atoms (crystallographic planes) and along rows of atoms (crystallographic directions), as shown thus:



Some important phenomena are associated with the deformation of metals. For example, the stress required for yielding is increased with prior plastic deformation. This is called strain hardening. Properties such as electrical conductivity, thermal conductivity, and ease of magnetization are altered by plastic deformation.

In any aggregate of grains such as composes industrial metals, it is difficult to investigate the effect of deformation because of the interaction of the grains with one another. Consequently it has become necessary to develop techniques for isolating individual grains, or for growing single grains large enough to handle and study effectively.

In the metallurgy section at Johns Hopkins there are especially designed furnaces capable of growing single crystals of metals two feet long whose melting points do not exceed 1100°C. There has recently been developed at Hopkins a method for growing large

crystals of the refractory metals with extremely high melting points, such as molybdenum, wulfram, tantalum, and columbium.

The Hopkins group is actively engaged in studying structural changes accompanying the plasticity of molybdenum single crystals. These investigations are sponsored by the Office of Naval Research. The increased need in industry for metals with high strength at high temperature has necessitated investigations of all the high temperature metals.

Molybdenum, whose melting point is 2625°C (4760°F), has good strength at fairly high temperatures; its ore is readily available in the United States. There are, however, certain difficulties encountered in its use as a pure metal or base metal alloy. Pure molybdenum oxidizes at relatively low temperatures. It is brittle at room temperature and hence cannot easily be fabricated to the finished product. The single crystal of molybdenum, however, is not brittle. On the contrary, the single grain has been extended seventy-five per cent at room temperature; it has been rolled ninety-eight per cent to a very thin sheet.

This points rather conclusively to the fact that the embrittling component in commercial molybdenum is located in the grain boundaries, since the material without a grain boundary is ductile. The problem is now narrowed down to the point where the demon in the grain boundary must be isolated and rendered innocuous, or eliminated entirely.

During the past thirty years there have been few investigations concerned with the structural changes which accompany the plastic deformation of body centered cubic metals. At the present time, there exist three main theories dealing with the deformation of this class of metals; however, these theories do not satisfy the observations reported in the literature.

Since molybdenum is one of the body centered cubic metals, the basic aspects of the manner in which it deforms are of tremendous importance in deriving a sound theory of the plastic deformation of this class of metals. The structural changes resulting from the gliding of planes of atoms over one another are being studied with aid of x-rays. For example, figure 1 shows a back-reflection Laue photogram of an undistorted single crystal of molybdenum; figure 2 shows a back-reflection Laue photogram of the same crystal after it has been extended less than one-half of one per cent.

The pattern in figure 1 is typical of any undistorted body centered cubic metal structure. The elongation of the spots (asterism) shown in figure 2 indicates that the relatively perfect periodicity of the atoms composing the strain-free crystal is altered by the small plastic extension. The planes of atoms over which gliding has occurred (in order to allow the metal to alter its shape) are no longer perfect planes but are slightly bent. The stress necessary to cause plastic flow within a perfect order must be increased when the structure is disturbed in some way, such as by prior plastic flow. This is a simple explanation of the phenomenon of strain hardening referred to earlier.

Of primary importance in the construction of an explanation for the

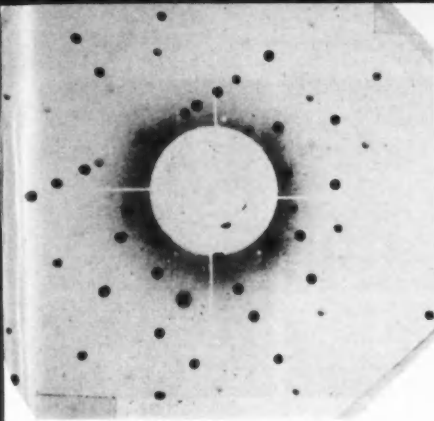


Figure 1

➤ An undistorted *single crystal of molybdenum is shown (above) in its typical structure by a Laue photogram.*

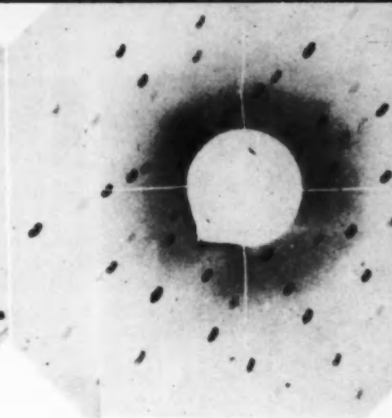


Figure 2

➤ After *slight extension the same crystal has been greatly altered, as seen in the elongation of the spots.*

plastic behavior of the body centered cubic class of metals is the determination of the crystallographic nature of the deformation process. Here, the x-ray is of tremendous importance. The glide elements, referred to earlier, are generally determined by observing the traces at high magnifications in such a manner as to resolve the traces on a projection.

In the simple case of traces from only one set of crystallographic planes this method is accurate. In the case of molybdenum, however, where there is more than one set of traces, the observation method results in an integrated trace which may not represent the true crystallography of the deformation process. The x-ray beam, on the other hand, delineates the structural changes on an atomic scale.

By analyzing the x-ray photograms made after progressive deformation of molybdenum crystals, Dr. N. K. Chen and the writer have been able to show that what formerly were considered as traces of more than one type of plane are actually the traces of non-parallel high atomic density planes of the same type. This very important discovery has simplified the deformation picture considerably, and it is felt that additional work in progress will aid measurably in this basic problem.

A series of studies of the structural changes accompanying plastic deformation in wulfram, columbium, tantalum, vanadium, chromium, and iron is under way in the metallurgy section under sponsorship by the Office of Naval Research. With the participation of graduate students, new basic facts are being uncovered which should contribute to a more sound theory of physical plasticity.

The problem of plastic deformation of metal single crystals is being investigated in still another way. Professor R. B. Pond, of the Hopkins

> **Formation** *of lines of glide can be watched with apparatus designed by Professor R. B. Pond. These high-speed photographs show the progressive formation of lines during the extension of a single crystal of aluminimum. Figures are film frame numbers, sequence covers about two and a half seconds.*

573

938

metallurgy section, has developed a small hydraulic tensile apparatus. With this equipment it is possible to extend small single crystals on the stage of a metallograph, so that the deformation can be observed at high magnifications while it is going on. Stress and strain are being measured at the same time that high speed motion pictures are taken at high magnifications.

An example of some of the results by this method are seen in these pictures. The material here is a small single crystal of aluminum grown to a particular shape and treated so as not to introduce any strain before the documented deformation. There, the progressive formation of lines of glide may easily be seen. This work, sponsored by the Office of Air Research, has uncovered many basic facts which have aided in the overall picture of the plasticity of metals.

A very basic problem being studied at Hopkins is the manner by which metals solidify. The transformation from liquid to solid almost always produces a characteristic tree-like structure called a dendrite. An example of the appearance of a dendrite may be seen in the picture on page 24.

In order to control certain variables in this investigation, molds of copper were specially designed. The molds, coated on the inside with a very thin layer of graphite, are set into a talc block over a nichrome heating coil. Percussion-welded to the bottom of the mold at each quarter inch position are iron-constantan thin wire thermocouples, whose leads are passed out through the talc into an ice-water cold junction. From there, they are connected to a battery of microammeters. The copper boat is welded to a copper cooling block which is connected to a copper pipe used as a conveyance for cooling media.

High purity tin is melted in the mold and solidified, using different cooling media. The temperature gradient above the melting point and during the solidification process is carefully recorded by photographing the meters and a stop watch as the solidifying interface (visible on the surface) passes the thermo-couple stations. In this manner, a carefully documented time-temperature relation is

1700

2200

3750

obtained. The orientations of the resulting grains are determined either by x-rays or by optical goniometry. By carefully controlling the heat input, equilibrium between a solid-liquid interface has been maintained for periods as long as four hours.

Careful metallographic study has resulted in a theory for the mechanism of growth of the dendrite form in metals. The dendrite or tree-like form is seen on the surface as longitudinal striae, aligned almost parallel to the direction of growth of the grain. These observations are, of course, made on the surface of a solidifying liquid.

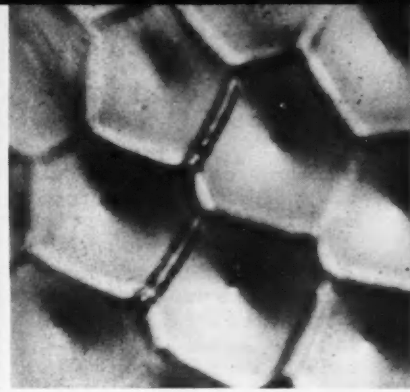
For a three dimensional picture of the dendrite, it is desirable to obtain an end view of the growing metal. This is accomplished by connecting a vacuum pump to a glass tube in the solidifying liquid. At any desired time and position of the liquid-solid interface, the liquid can be removed almost instantaneously by connecting the vacuum, thus leaving the bled solid interface. In this manner the end view of these longitudinal striae can be studied. The photographs on page 25 and on the back cover show the network of hexagons characteristic of solidifying metals.

Professor Pond's explanation for the growth of the hexagons, which he has termed mammiforms, is based upon an analysis of the thermal gradients and thermal diffusion. A mechanism has been constructed by which it is possible to explain the characteristic shape of dendrites. In brief, the nuclei of mammiforms are deposited at positions on a growing face. Because of heat dissipation along the surface, into the liquid, and back into the solid, the positions of these nuclei are symmetrical. The growth into their characteristic shape is determined by the heat dissipation and diffusivity of impurities. In a similar manner, the tree-like appearance of the dendrites is explained.

Research recently completed at Hopkins by Dr. I. R. Kramer was concerned with the measurement of delay time for the initiation of glide in single crystals of alpha brass, aluminum, and beta brass. Dr. Kramer constructed a pendulum which permitted the crystals to be subjected to a constant stress for various periods of time. He found a delay time for glide

➤ A TREE-LIKE *structure called a dendrite is characteristically produced when liquid metal hardens. Hopkins researchers are trying to explain their formation.*

➤ The surface *of solidified tin, magnified sixteen times, shows dendrite arms in the form of striae.*



➤ The ends *of the dendrite striae, photographed as they are being formed in the metal, are hexagonal.*

when the specimens were tested below room temperature. No delay time, however, was found for the face centered cubic metals, alpha brass and aluminum, at temperatures as low as —190°C for impact times as small as 8×10^{-5} seconds.

From these findings, he is able to explain why the body centered cubic metals fail in a brittle manner below a certain temperature and fail in a ductile manner above this temperature (brittle transition temperature), whereas the face centered cubic metals in the body centered cubic beta brass do not behave in this manner. This theory proposes that the existence of a delay time for the initiation of glide will permit a specimen to be loaded at a rate sufficiently rapid so that the delay time is not exceeded. If, under these conditions, the stress is sufficiently high to cause fracture, plastic deformation cannot occur and the specimen must fail by cleavage.

The importance of metallurgy in today's world needs no great emphasis. The need for metals which will withstand extremes in temperature and also have thousands of special properties and applications has necessitated fundamental investigations of the solid state. The Hopkins metallurgy research program together with the graduate activities in meallurgy is making substantial contributions to the better understanding of the solid state.

On the Back Cover

➤ Magnified greatly, *the end of a block of solidifying tin shows a characteristic hexagon pattern.*

For the Home Lab

Five Cents Worth

by Burton L. Hawk

➤ Once upon a time, the American five cent piece was worth five cents. With a nickel one could buy a candy bar, cigar, ice cream cone, soft drink and even a hot dog or loaf of bread. But now the nickel is only part payment on these items and about the only thing it can be used for is in the church collection plate.

But the monetary value of the coin does not interest us (much), for we are concerned with what it is made of rather than its worth. Strangely enough, there is very little nickel in a nickel. Actually, it is 25% nickel and 75% copper. Having nothing better to do, suppose we see if we can determine the presence of the two metals in a nickel.

First, obtain the nickel. During the war years, nickel was so badly needed that its use in coinage was curtailed and silver was used instead. So try and obtain a nickel dated prior to 1941 or after 1947. We don't want our nickel coins adulterated with silver.

Clean the coin thoroughly with steel wool and cleanser. Then drop it into a dilute solution of nitric acid. If necessary, apply more heat and add additional acid from time to time until the nickel is entirely dissolved; then, filter. We now have a solution of copper and nickel nitrates.

How shall we separate the two compounds? Both nitrates are soluble in water and alcohol. Both hydroxides are greenish-blue and both are soluble in acids and ammonium hydroxide. Both oxides are black and soluble in acids. Both sulfates, chlorides and acetates are soluble, whereas both sulfides, carbonates and oxalates are insoluble.

Before we proceed further, suppose we transfer our compounds to the chlorides. First add a solution of sodium hydroxide to the mixed nitrates forming a precipitate of nickel and copper hydroxides. Filter off, then add more sodium hydroxide to the filtrate and re-filter. Combine the two precipitates and dissolve the mass in dilute hydrochloric acid. We now have a solution of copper and nickel chlorides. Thinking of copper chloride brings to mind the fact that *cuprous* chloride is insoluble in water! Of course, our solution contains *cupric* chloride. Why not add a reducing agent to precipitate the copper as cuprous chloride? You can, if you wish. Add a solution of stannous chloride and filter off the precipitate. You will then have a solution of nickel chloride—but, mixed with tin!

So, let's plan another attack. We find there is one difference in the two sulfides. Copper sulfide is precipitated by hydrogen sulfide in the presence of acid, whereas nickel sulfide is not! Take your solution of the two chlorides and add a little more hydrochloric acid just to make certain that the acid will be in excess. Next, bub-

ble a stream of hydrogen sulfide gas into the solution. (The hydrogen sulfide is generated by the action of dilute HCl on iron sulfide). Or, if you prefer, add a solution of sodium sulfide. Copper sulfide will be obtained as a black precipitate. Filter it off and again add sulfide to the filtrate. No doubt additional copper sulfide will be precipitated. Filter the second time and combine the precipitates. Save the filtrate, which should be nickel chloride.

Of course we do not want copper in the form of the sulfide. So let's get it back to the chloride again. This is done by dissolving the sulfide in concentrated hydrochloric acid. It will dissolve with difficulty and you will have to coax it along, using heat if necessary. Dissolve as much as you can; then filter.

Now we have a solution of copper chloride and a solution of nickel chloride (we hope). Pour some of the copper chloride in a watch glass and drop a clean nail in the solution. It will soon be covered with pure copper, displaced by the more active iron.

You can easily verify the presence of nickel in your nickel chloride solution by adding a few drops of dimethylglyoxime solution. This famous "nickel-testing" reagent forms a scarlet red precipitate even in very dilute solutions of nickel.

Now if you feel ambitious, you can actually obtain the metal. Add sodium hydroxide to a portion of your nickel chloride solution. Filter off the nickel hydroxide, dry, and heat strongly to obtain black nickel oxide. Transfer this to a charcoal block and heat strongly in the reducing portion of a blowpipe flame. Examine the residue carefully for minute traces of metal. If it is nickel, it will be attracted by a magnet.

Well, this experiment has cost you at least one good nickel. We hope that you have received five cents worth of enjoyment from it.

Unbalanced Equations

Not Many, We Hope

Dear Anne:

I should like a recipe for springerle cookies using baking ammonia. Also what is the correct name for baking ammonia?

—D. N. B.

➤ THE NAME by which you can buy baking ammonia at drug stores (some of them) is powdered carbonate of potassium.—*Ask Anne, in The Washington Post.*

Virus Conquest Will Be Chemical, Not Vaccine

Virus Studies Point New Hope

➤ IF VIRUSES such as cause infantile paralysis, influenza and other serious diseases are conquered, it will be through chemicals, not vaccines.

Evidence in favor of this view was reported by Dr. Frank L. Horsfall of the Rockefeller Institute, New York, at the Second International Poliomyelitis Conference in Copenhagen recently.

The chemicals will act by interrupting the multiplication of the virus within the cell it has attacked. Some chemicals which can stop viruses in this way have already been found.

In infections with pneumonia virus of mice, the multiplication of the virus can be stopped by giving the mouse a complex sugar which occurs in the outer envelope or capsule of a bacterium responsible for a rather rare type of pneumonia in man. The organism is known as the *Klebsiella pneumoniae* and the sugar is known as a capsular polysaccharide.

This same capsular polysaccharide also has the ability to interrupt the multiplication of mumps virus in the cells of the living chick embryo, Dr. Horsfall reported.

Two chemical compounds have been found which are capable of interrupting the multiplication of the virus of Influenza A in tissue cultures, he said. They are dl-methoxinine and dl-ethionine.

Other chemicals were used successfully to inhibit the multiplication of two types of bacteriophages, viruses which attack and destroy bacteria.

Stopping virus diseases by vaccines depends on the theory that the body produces antibodies in reaction to specific viruses that invade it. This view is widely accepted but Dr. Horsfall believes the antibody idea is not adequate to explain many phases of recovery from virus diseases.

For instance, he said, no one has ever found antibodies in plants, yet they recover from virus infections. Also some virus diseases, like herpes simplex (cold sores) run their course despite abundant antibodies, while others, like psittacosis (parrot fever), display much active virus, but little antibodies.

Dr. Horsfall offered instead of antibodies the suggestion that the invading virus and some cell chemical system, limited in extent, strike some sort of balance.

10 Viruses Range Globe

➤ A GROUP of about 10 viruses, all related in unique but complicated ways, ranges over almost the entire globe.

Many of them can cause severe sickness in man and his domestic animals.

Regions of the world included in their range are eastern Asia, Japan and many of the Pacific Islands, the United States, Central Africa, the United Kingdom, Central Europe, Columbia and Brazil.

These 10 world-ranging viruses

may all come from a common stock, or ancestor. They are all about the same size. In most cases they are carried to man and domestic animals by infected mosquitoes. In every instance, however, there is probably some wild reservoir in nature.

Monkeys play a prominent role as reservoir for the yellow fever virus. Various birds are involved in four kinds of encephalitis, the brain disease sometimes called sleeping sickness. Besides the birds involved as reservoirs in St. Louis, eastern and western equine (horse) and Russian encephalitis, rodents have been incriminated in Russian encephalitis.

A systematic study of new viruses found in South American and African forests has been carried on by the International Health Division Laboratories of the Rockefeller Foundation.

Viruses Battle Cancer

➤ STRANGE disease-causing viruses from Africa and South America are now being used in the battle against cancer.

Almost 100 cancer patients at Memorial Hospital in New York City have been given this virus-against-cancer treatment during the past two years.

The treatment has not yet produced any cures. In fact, the doctors there "don't think we have ever done any patients any good," one of them said. But they keep on trying in the hope of hitting a virus that will do the job of killing cancer cells without harming normal cells.

This approach, selective killing of cancer cells, offers the best solution to the cancer problem, Dr. Geoffrey Hadfield, professor of pathology at the Royal College of Surgeons, London, declared at a recent meeting of the Medical Society of the District of Columbia. He believes that scientists are in sight of success in this direction.

The idea of using viruses to stop cancer is not new. For more than half a century doctors have reported occasional cases of a cancer patient improving remarkably when he had gotten some germ-caused disease.

Development of sulfa drugs, penicillin and other antibiotics which stop so many disease germs has led scientists at the University of California to try deliberately infecting cancer patients with a disease that can be cured in the hope it will stop the cancer. A few dramatic improvements have been reported, but they were only temporary.

At Memorial Hospital scientists found a number of viruses which would completely destroy cancers in mice and fowl without harming the animals. Some of these viruses do not, so far as is known, cause serious disease in man. It is these viruses which have been given trials on patients. Although the patients have not been helped except perhaps temporarily, the scientists have been encouraged because they occasionally find the virus in the cancer. This means that they are getting a virus which will select cancer cells to grow on in preference to other cells in the body.

Right now they are working, first, to get human cancers to grow in an animal, such as a mouse. Then they are trying to get a cancer-killing but otherwise harmless virus to adapt it-

self to select these human cancer cells for its home.

Viruses May Cause Cancer

➤ WHETHER, under certain conditions, ordinary viruses such as cause diseases ranging from polio to common colds can induce cancer is a problem posed by findings reported to the Second International Gerontological Congress.

The findings, on cancer in birds, were presented by Drs. F. Duran-Reynals and B. A. Briody of Yale University School of Medicine.

In birds, these scientists reported, the cancer-causing viruses behave at first as ordinary viruses. They infect the chicken or other bird at an early age. They may induce a non-cancerous disease or they may not. But after this stage, the viruses remain in hiding in the bird until the bird later reaches a certain age, the cancer age. Then the virus shows itself as a cancer virus. It varies or mutates at this stage, probably under the influence of the age factor of the bird that acts as the virus host.

Through this mutation or variation, the virus becomes capable of causing a great variety of tumors or leukemias.

Later, through further effects on the virus, the age factor suppresses fundamental attributes of malignancy, such as steady growth. Masking of the virus and regression of the tumor may result.

Energy Tossed Between Molecules

➤ ENERGY can be passed between molecules over relatively long distances, very much as a fast basket ball is passed. This discovery has been made by Drs. Margaret M. Moodie and C. Reid of the University of British Columbia's department of chemistry.

Extremely efficient transfer of energy occurs when two chemicals are dissolved in a rigid glassy material and irradiated by light of a wavelength absorbed by one of the substances, but not by the other or the material in which they are dissolved.

This phenomenon takes place when the material which picks up the energy is in the form of microcrystals rather than dissolved.

In the discovery experiment anthracene emitted light, the energy of which was transferred to microcrystals of naphthacene, suspended in a glass of ether-isopentane-alcohol.

The scientists believe that the energy transfer which was a thousand times more efficient than when both substances are dissolved is either because the absorbing molecules have become lined up with the orientation of the glass, or that it is a phenomenon of the surface of the microcrystals themselves.

Such energy transfers are very important in the respiration process in living animals and in the process of photosynthesis by which the sunlight's energy is captured by the green plant. The new discovery may throw light on these two processes.

Fertilizers and Soil
Assayed For Usefulness

Chemical Aid to Farmers

➤ GARDENERS and farmers now have assurance based on atomic evidence that when they add superphosphate fertilizer to their soils the phosphate is very soon available to their plants and crops.

Two Swedish scientists, L. Frederiksson and Olle Gunnarssen, of the Statens Jordbruksforsok, Upsala, recently proved this by adding radioactive phosphate fertilizer to soil and then dissolving out the water-soluble phosphorus and measuring the proportion of radiophosphorus.

This water-soluble material is the "plant available" phosphorus of the soil and the experimenters found that regardless of the amount of radiolabelled fertilizer they added it was soon thoroughly mixed with the plant available phosphorus and was proportionately extractable.

Plants growing in the treated soil began to take up the radio-active phosphorus of the fertilizer very soon after it was added to the soil and in quantities equivalent to the relative amount of added phosphate.

The results of their experiments led the Swedish investigators to conclude that there is in soil a definite quantity of "plant available" phosphorus, part of which is in the soil solution and part "bound" to the soil colloids but in dynamic equilibrium with the portion in solution.

Triple Crops in South

➤ THE SOUTH can triple its corn crop and get 22 instead of 14 bushels of wheat per acre by higher rates of fertilization and other good farming practices.

The figures for these and other increased crop yields from better fertilization come from a state-by-state survey completed during the summer by the National Soils and Fertilizer Research Committee, headed by Dr. R. Q. Parks, soil scientist of the U. S. Department of Agriculture.

Tobacco growers, the committee found, are getting only about 78% of the land's potential yield, though the tobacco crop is one of those now getting heaviest fertilization. The others getting heaviest fertilization are the vegetable, fruit and nut crops.

Southern farmers now are getting an average yield of 26 bushels of corn per acre.

A combination of heavier fertilization, the use of adapted hybrids, close spacing, and other good management practices would triple yields, the committee reports. This would mean more than a billion additional bushels from approximately 24 million acres, planted in 1949. It would require an estimated 720 thousand tons of nitrogen. Total U. S. consumption of nitrogen in 1949 was a little more than a million tons.

The cotton crop can be increased by about 10% from its present yield of 640 pounds per acre.

The survey covered more than 250 million acres in 13 Southern states: Virginia, North Carolina, South Caro-

lina, Georgia, Florida, Kentucky, Tennessee, Alabama, Mississippi, Arkansas, Louisiana, Oklahoma and Texas. Reports are being compiled on surveys for the Northeast, North Central and Western regions and for the United States as a whole.

New Test For Alkali

➤ WHETHER or not alkali in the soil will interfere with plants growing may now be determined in 60 hours in many cases. A new test developed under the direction of Dr. Roy Overstreet, professor of soil chemistry at the University of California's College of Agriculture, can check the soil any time of year in the laboratory. Materials necessary for correcting alkali soils can then be applied before a crop is planted.

This is not a test of soil fertiliy, Dr. Overstreet emphasized. It is a measure of soil toxicity. Alkali soils are usually fertile after the salts are removed. The test can also check the efficiency and speed of materials used to correct an alkali soil.

Radish seedlings are used in Dr. Overstreet's test. Thirty-six hours after germination the seedlings are placed in a sample of alkali soil. The growth in the next 24 hours tells whether the soil contains too much alkali. Too much sodium and sodium salts in the soil inhibit plant growth.

Further experiments are underway to find out if this test can be applied to other types of soils.

Nitrogen from Heaven

➤ NITROGEN—vital to the fertility of the soil—comes sifting down from the atmosphere onto the ground at the rate of 5.8 pounds per acre per year. This is called a "significant" amount by DeLoss H. Matheson, chemist and bacteriologist of Hamilton, Ontario, Filtration Plant. He reported in the *Canadian Journal of Technology* on the results of 18 months of study of the fall of inorganic nitrogen compounds on the earth and bodies of water near Hamilton.

It was found that rain and snowfall produce more nitrogen than dry days, but that there were many variations on days when there was no moisture. Explanations of these variations, he said, would have to be found in more complex changes in atmospheric conditions than could be determined by the observations made in this study. Generally, it was found, short, sharp rains yielded more concentrated solutions than did longer precipitations.

Mr. Matheson found that, during the period covered by his investigation, the total nitrogen fall was consistent with amounts previously reported by other investigators.

Fresh vegetables, to retain nutritive values, should be cooked fast and with only enough water to prevent scorching.

Aluminum is not the lightest metal as many suppose; lithium, sodium, potassium, calcium, beryllium, magnesium are lighter.

Metabolic Patterns
Key Obscure Diseases

Individual Food Needs Vary

➤ HOPE for treatment of mental disease through the diet is held out by Dr. Roger J. Williams of the University of Texas department of chemistry.

Dr. Williams, in a talk before the American Chemical Society, said that the possibility of treating numerous obscure diseases by giving attention to special genetically controlled needs is real and may result in at least a minor revolution in the field of medicine.

Because mental powers are in some cases demonstrably correlated with individual metabolic patterns, the study of the latter offers a bridge between biochemistry and psychology and an open door to a better understanding of mental disease. There is a probability that nutritional treatment based on individual needs may be developed.

As evidence of at least one ailment that could be traced to diet, Dr. Williams cited alcoholism. It definitely has roots in the characteristic pattern of an individual's use of food, he said, and has been treated successfully by nutritional means.

Dr. Williams predicted that a whole new pharmacology will ultimately have to be developed, based on a recognition of individual metabolic patterns. The difference in effect of a particular drug among various individuals is dependent on the individual pattern, he said, and such individual responses can make the differences between life and death.

The more useful drugs, he noted in this connection, are those which have a relatively uniform action; large numbers of chemicals, however, never have been used because they cannot be relied upon to produce predictable results. Even the most uniformly acting drugs, moreover, depart significantly from the "norm" when applied to a substantial number of cases. The efficient use of drugs, he indicated, would require preliminary study of individual dietary need.

Dr. Williams based his conclusions on the fact that each human individual possesses a distinctive metabolic pattern which is intimately related to his health and other problems. The existence of these patterns, he said, is a reflection of the existence of different enzymatic patterns.

The enzymes to which Dr. Williams referred are chemicals found throughout the body which carry on the life functions without being destroyed or changed too greatly in the process. Some enzymes, for example, are secreted and digest food in the stomach. Others in other organs can combine basic chemicals in such a way as to form living matter.

It is believed that animals inherit their enzymatic patterns from their parents, and the pattern of the offspring may be a mixture of that of the parents. But the existence of dif-

ferent enzymatic patterns for different individuals, he said, is caused not by the *absence* and *presence* of different enzymes — these are presumably substantially the same in all individuals — but by the variation of relative efficiencies of the different enzyme systems.

These differences in enzymatic patterns, he concluded, in turn must make for difference in the need for the various raw materials required for body building. The list of nutrients required by a series of human individuals may be identical, yet the pattern of needs may be different from individual to individual. All this adds up to the fact that diet influences mental and other diseases through metabolic patterns.

Wasp Venom for New Insecticides

➤ FROM THE powerful venom of a tiny parasitic wasp, scientists of the Connecticut Agricultural Experiment Station hope to be able to produce new poisons to fight insects.

The wasp venom produces a paralysis that affects the nerves and acts fatally in a different way from DDT, parathion (a nerve gas insecticide) and any other commonly used insecticides.

Caterpillars of the wax moth attacked by the wasp experience a sort of living death, with digestion unharmed, heart beating, and even muscles remaining in good working order even though completely paralyzed. They die after a few days.

Dr. R. L. Beard, entomologist, who made the studies, hopes that by determining the mode of action of the powerful venom, similar synthetic materials may be produced in the laboratory that would have the same deadly effect on insects.

One drop of wasp venom barely seen through a microscope can kill more than 1,600 caterpillars, each many times the wasp's size. This was proved by injecting successively caterpillar blood into other caterpillars. The wax moth upon which these tests were made is notorious for its ability to resist insecticides.

To human beings who suffer from wasp stings, there may come some help from understanding just how the venom does its damage. Scientists recognize that different people react differently to stings.

Some wasps paralyze the larvae of other insects in order to provide a fresh supply of food for their young when they hatch out and start to grow.

The relatively new silicone greases used in lubrication are claimed to last at least ten times as long as the best organic lubricants.

The death rate from beriberi has decreased in some sections of the Philippines where the ordinary white rice used for food is enriched with vitamin B_1, niacin and iron.

Diet-Induced Cirrhosis Avoided in Germ-Free Rats

Antibiotics Ward Off Liver Disease

➤ PREVENTION of liver diseases — a world-wide health problem — may be made easier through experiments with antibiotics and germ-free animals which were described to the American Chemical Society by Dr. Paul Gyorgy, professor of nutrition in pediatrics at the University of Pennsylvania School of Medicine.

He fed animals deficient diets, which ordinarily cause necrosis or destruction of the liver. But animals that were given certain antibiotics at the same time did not get the disease so quickly, apparently because of the action of the antibiotics against bacteria in their intestines.

Germ-free rats, from the Germ-Free Life Laboratory at the University of Notre Dame, lived twice as long as non-germ-free rats which were fed the same diet. The non-germ-free rats died of massive hemorrhagic necrosis of the liver. The germ-free rats at autopsy showed no necrosis of the liver.

Their weight curve throughout the whole experiment was very satisfactory, in contrast to the flat curve of the control animals, Dr. Gyorgy said. This phase of the experiments was carried out in cooperation with Professor J. A. Reyniers and his associates at the Germ-free Life Laboratory.

Studies by Dr. Gyorgy up to 1950 in the experimental approach to diseases of the liver have produced four outstanding results which he reported.

1. The recognition of purely nutritional factors as important in determining causes of hepatic (liver) injury.

2. The prevention, arrest, and even possible reversal of this pathologic process simply by proper change in the composition of the experimental diet.

3. The interrelation between dietary and endocrine (hormonal) factors in the development of liver injury.

4. The concept that experimental dietary injury to the liver is often combined in the same animal with specific manifestations in the kidney, in particular with acute necrotizing nephrosis (death of kidney tubules).

Diet factors that helped prevent cirrhosis of the liver (excessive formation of connective tissue) had one common denominator — a sufficient supply of choline, a substance believed to be a member of the vitamin B complex, and its precursors, including the amino acid methionine. The benefit seen after administration of vitamin B-12 may be due to its choline sparing effect, Dr. Gyorgy said.

In acute liver disease with massive necrosis or destruction, the beneficial dietary factors are cystine and methionine, both amino acids, or vitamin E.

Since vitamin E and amino acids are so different chemically, he said, it is difficult to reconcile pure deficiency as the possible cause of dietary hepatic

necrosis with the interchangeability of those compounds in preventing liver necrosis.

The assumption has been made that their beneficial effect more probably results from an underlying detoxifying mechanism than from the supply of a deficient nutritional factor. In the case of dietary hepatic necrosis, such toxic factors may originate in the intermediary metabolism, or under the influence of the intestinal flora.

So, said Dr. Gyorgy, since 1950 the researchers have sought to eliminate or modify the intestinal bacteria by giving antimicrobial drugs. Polymyxin, chloramphenicol (chloromycetin) and bacitracin were found ineffective. Sulfoguanidine and streptomycin were only slightly effective.

Neomycin, penicillin, terramycin and aureomycin exerted a very definite delaying effect on the production of experimental necrosis of the liver.

The differences may depend upon the varying range of bacteria against which each is effective and on the ease with which they develop resistant strains in the intestinal flora.

With successive experiments, carried out during the last year and a half, the protective effect of aureomycin on hepatic necrosis became less pronounced. When experiments were set up in other "uncontaminated" laboratories under identical conditions, the beneficial effect of aureomycin became again strongly evident.

All the antimicrobial agents tested produced temporary stimulation of growth in the experimental animals. Furthermore, the beneficial effect of aureomycin and terramycin was not limited to the delay of hepatic necrosis but manifested itself also in the prevention of hepatic cirrhosis in rats.

The experiments with the germ-free animals have been made in the last 18 months.

Liver disease and its prevention are a world-wide problem with all its by no means negligible implications, Dr. Gyorgy said. Cirrhosis of the liver exists in a very large proportion of the population over a wide tropical belt, together with general malnutrition, based chiefly on low intake of protein, especially animal protein.

Improved health, improved nutrition will give the population in the Tropics a better balance of physical and mental abilities. It should also improve their general outlook on life and assure them a better future.

Spring Odor due to Drug Organism

➤ THAT spring-like odor of freshly plowed soil is due to the same kind of organisms that produce streptomycin and other antibiotic drugs so useful in combatting disease.

Dr. Selman A. Waksman, the discoverer of streptomycin, can demonstrate the pleasant smell of these microscopic organisms, called actinomycetes, by letting visitors to his Rutgers University laboratories sniff the cultures from which the antibiotics are obtained.

The organisms, which some scientists classify among the bacteria and others among the molds, keep the soil free of dangerous disease-causing invaders by producing their antibiotic substances.

Stable, Inert, Non-Flammable, Fluorine Compounds Find Use

Fluorochemicals Assume New Jobs

➤ NEW CHEMICALS with a host of unusual uses are coming from the once-untamed gas fluorine, Dr. James O. Hendricks of the Minnesota Mining & Manufacturing Company, St. Paul, Minn., told the Diamond Jubilee Meeting of the American Chemical Society.

Uses, present or foreseen, include flame-extinguishers, lubricants that withstand great heat, coolants for electrical equipment, aids in electroplating, new resins, and as tools to separate and purify rare metals in atomic energy studies.

Fluorochemicals is the name applied by Minnesota Mining & Manufacturing Company to organic compounds which are completely or almost completely fluorinated, said Dr. Hendricks, who is assistant director of the company's central research department. The industrial potential of fluorochemicals has been slow in developing due to the lack of a simple economical means of production. Heretofore, only the simpler molecules or polymers of simpler molecules have been available commercially. Examples of such compounds are Freons, Teflon, Genetrons, and Kel-F. The discovery of the electrochemical fluorination process, by Dr. J. H. Simons, of Pennsylvania State College, has greatly increased the number and types of fluorinated organic compounds which can be produced on a practical scale. The commercialization of this process by the Minnesota Mining & Manufacturing Company is well under way.

A series of perfluoro organic acids, starting with perfluoroacetic acid, have been made in the electrochemical cell. A number of applications of the perfluoro acids are developing. The Atomic Energy Commission has published papers on the separation and purification of certain rare metals by means of thenoyl trifluoroacetone (TTA). Hafnium can be separated from zirconium rather efficiently. In the preparation of the radioisotope carbon-14, the impurity scandium is removed by using TTA. These processes are of interest to the AEC. Trifluoroacetic acid can be used as one of the starting materials for the preparation of TTA.

The higher perfluoroacids, for example, perfluorocaprylic, and their salts lower the surface tension of water solutions to a very unusual degree. No known soaps or surface active agents will reduce surface tension of water as much. One industry which may use these stable surface tension lowering materials is electroplating. It is envisioned that foams for numerous purposes could be logical uses. Recently issued patents indicate that the salts of the higher perfluoro acids act as dispersing agents in the polymerization of Teflon.

Highly fluorinated materials are characterized by high specific gravity, low refractive index and non-flammability. An example of a high boil-

ing liquid of this type is the pentaerythritol ester of perfluorobutyric acid. In many ways it resembles the liquid fluorocarbons, but its viscosity changes less with changing temperature. Examples of other highly fluorinated liquids are triperfluorobutyl amine and diperfluorohexyl ether. The basic character of each compound has entirely disappeared and they resemble the perfluorocarbons in this respect. The compounds are remarkably stable and can be heated to 500° in the absence or presence of air. The dielectric constant of each is very low, less than 2. These liquids have interesting possibilities in precision instruments where their non-corrosiveness, high density and heat stability are important. Their low dielectric constant may make them suitable for use as liquid coolants in electrical equipment where very high frequency pulses are encountered.

Liquid polymers of trifluorochloroethylene (Kel-F monomer) are finding specialized uses as lubricants because of their high temperature stability and lubricity. The newer perfluoro liquids mentioned above may also find application for this purpose. They remain liquid over a wider temperature range.

Vinyl perfluoroesters have been prepared by reacting acetylene with a number of the perfluoro acids, starting with the C_2 acid and going as high as C_{10}. The monomers polymerize to yield transparent, colorless, thermoplastic resins.

Polyvinyl perfluoroacetate has been made before, but the higher vinylesters and polymers are new. These polymers are still in the experimental stage. They are soluble in a number of fluorinated solvents.

A whole host of derivatives has been made from the perfluoro acids. Some required new syntheses and others were prepared according to methods already worked out in the hydrogen series. Especial attention is called to the perfluoro aldehydes, an entirely new class of perfluoro compounds. These were first announced by D. R. Husted at the 1949 fall Atlantic City ACS meeting. They form polymers which have shown resistance to hot, concentrated nitric acid. These are still in the laboratory stage of development.

A special derivative of trifluoroacetic acid is trifluoromethyl bromide (CF_3Br). It has exceptional efficiency as a flame extinguisher. It has the advantage of relatively non-toxic byproducts in comparison with other flame extinguishers after a flame has been put out.

AEC Fluorine Technology

➤ SIGNIFICANT results of research in the fields of fluorine and fluorocarbon technology have been made generally available by the United States Atomic Energy Commission in its publication, "Preparation, Properties, and Technology of Fluorine and Organic Fluoro Compounds."

This volume, the 18th in the National Nuclear Energy Series, was edited by Dr. Charles Slesser of the Commission's New York Operations Office and comprises forty chapters dealing with research sponsored during World War II by the Office of Scientific Research and Development, and the Manhattan Engineer District.

Fluorine-containing organic com-

pounds are of particular interest to science and industry because of their high-temperature stability and chemical inertness. In addition, since they have been prepared in gaseous, liquid and solid states, it is likely that they can be obtained in any desired consistency. Fluorocarbons are being used increasingly as lubricants, dielectrics, and plastics and have potential application as dyes, pharmaceuticals, fire-extinguisher fluids, heat-transfer media, and insecticides.

Four of the industrial organizations and four of the academic institutions which conducted major projects in the field contributed the forty detailed papers which constitute the 892-page book. Each paper offers a complete story of an important segment of the overall study. In all cases the author has been closely associated with the research described.

The institutions that participated in the project and contributed papers are: E. I. duPont de Nemours and Company, Harshaw Chemical Company, Hooker Electrochemical Company, The Johns Hopkins University, The Kellex Corporation, Massachusetts Institute of Technology, Purdue University, and the SAM Laboratories, Columbia Area. The book is published by McGraw Hill.

Treasures in a Lump of Coal

➤ THOUSANDS of exhibits could be prepared for showing at a Science Fair, and the by-products from a lump of soft coal would not be exhausted. These exhibits may run the gamut from black liquids to clear solids, from medicinals to poisons, from riotous colors to delicate evanescent hues, from vile smells to the most fragrant perfumes.

When a lump of soft coal is heated in the absence of air it gives off coal gas—a fuel, ammonia liquor, light oil and a black, liquid coal tar. The solid left behind is coke. The process by which this is done is called destructive distillation.

This process alone can form the background for a number of student-made exhibits which may be simple or elaborate. When coal tar is distilled hundreds of different substances are obtained from which emerge thousands of other products. Look at the possibilities of exhibits relative to the coal tar dye industry alone. More than a thousand different color-fast dyes are available. A collection of some of these would make a sizeable exhibit.

Fluorescent dyes like uranine are used as sewage tracers or are employed to color a huge circle of water to mark the spot in the ocean where a plane or life-raft wallows in distress. Some dyes aid the bacteriologist in differentially staining tissues and bacteria. Again, there is the class of coal tar products from which stem the germ-fighting sulfa drugs, insecticides like DDT and methoxychlor; or weed killers and seedless fruit hormones like 2,4-D. Exhibits can be built around experiments made by students with some of these chemicals.

America's prosperity is due largely to ingenious minds which invented new machines and put them to work.

Chemical Patents

Write the Commissioner of Patents, Washington 25, D. C., to obtain copies of patent specifications. Order by number, enclosing 25 cents for each patent. Send money order or Patent Office coupon, but not stamps.

Carbon Black Production

➤ CARBON BLACK, an essential in the manufacture of automobile tires and used for many other purposes, is made from natural gas by an improved process which brought patent 2,564,736 to Charles A. Stokes, Wellesley Hills, Mass. Godfrey L. Cabot, Inc., Boston, has acquired the patent rights by assignment.

The process is characterized by burning streams of natural gas and oxygen, or a mixture of natural gas and oxygen, in a combustion chamber containing no air. The result is a larger yield of carbon black than obtained by older methods, and also the production of a synthesis gas that can be converted into liquid fuels.

Low-Cost Tool Steel

➤ ALLOY STEELS suitable for use in cutting tools which have a high degree of resistance against softening when subjected to temperatures in the range above 1100 degrees Fahrenheit are of relatively low cost. They are claimed to have better resistance to temperatures above 1100 degrees than other steels now available.

This steel alloy contains less than 3% chromium, 3% tungsten, 2% vanadium, 4% molybdenum and 1.2% carbon. Amounts vary from less than 1% to the figures given. This product of relatively low alloy content is hardenable by quenching and undergoes secondary hardening on subsequent tempering.

Inventor is Peter Payson, New York City. Patent 2,565,264 was awarded to him. Rights are assigned to Crucible Steel Company of America, also of New York City.

Cheaper Cheese Flavor

➤ BREAD or crackers with a pronounced cheese-like flavor, but which may contain no cheese, is made from any of the various types of flour used in leavened bakery goods by the addition of leucine, an essential amino acid, in a conventional dough formula.

Peter Kass, Great Neck, N.Y., received patent 2,564,763 for this invention. Interchemical Corporation, New York, has been assigned the patent rights.

Glass Fiber

➤ AN IMPROVED method of producing glass fiber suitable for use in making blankets for both thermal and acoustic insulation and many other purposes brought patent 2,563,080 to Charles J. Stalego, Newark, Ohio. The patent has been assigned to Owens-Corning Fiberglas Corporation of Toledo, Ohio.

In the process an elongated body of the "heat-softenable" glass is fed

along a path where it is subjected to a gaseous blast having a higher temperature than that required to soften the glass. The blast is opposed by another gaseous blast which makes the gases deflect outwardly, causing the glass to be shredded into fibers.

Gluing Creosoted Lumber

➤ CREOSOTED pieces of lumber can be glued together to form heavy structural timbers by a method on which a patent has been issued. Until this method was developed it was thought impossible to glue creosoted wood.

In the process, pieces of lumber which are to be glued together to form the heavy timbers are creosoted in the usual manner, even to the extent of high impregnation. Then thin layers of the surfaces to be bonded are removed by dressing or planing. The procedure from then on is the same as for untreated wood.

When wood is creosoted by the pressure method; creosote coated fibers are formed near the surface. Fibers deeper within the wood have received creosote only by penetration. The dressing process removes the creosote coated fibers, resulting in surfaces that glue will hold.

Inventors are Fred Denig, Pittsburgh, Pa., and Walter P. Arnold, Orrville, Ohio. They were awarded patent 2,563,821. Rights have been assigned to Koppers Company, Inc., Pittsburgh.

Aluminum-Magnesium Alloys

➤ ALUMINUM-MAGNESIUM alloys, suitable for either chill or sand casting, which have high tensile strength and ductility, are made by a process on which Charles B. Willmore, North Aurora, Ill., received patent 2,564,044. William F. Jobbins, Inc., of Aurora, Ill., has acquired the patent rights.

The chief difference between chill casting and sand casting lies in the rate of heat loss through the mold walls. In molds of sand it is slower than in permanent molds of metals or other materials in which the so-called chill casting takes place. Chill casting usually has the effect of decreasing grain size of the cast alloys, particularly when they are composed of an aluminum base.

In these aluminum-magnesium alloys, the magnesium content is less than 9% by weight. The improved properties are secured by the addition of very small quantities of titanium, beryllium, boron, and manganese or chromium .The castings have the desired improved physical properties without any following heat treatment.

Lawn Leaves Powdered

➤ LEAVES fallen from trees on the lawn are picked up, reduced to fine particles and returned to the grass to make humus by a manually-operated sweeper and disintegrator invented by Arvid Bjorklund, Minneapolis, Minn., on which patent 2,564,352 was issued.

It has a handle like a lawn mower for pushing, and geared wheels to operate the mechanism. It has rotating brushes much like a carpet sweeper to gather up the leaves. Inside is a disintegrator which includes a rotor with teeth. These convert the leaves into fine particles which are passed downward to the lawn.

Shark Meat Processed

➤ SHARK MEAT may become a more important human food with a process of preparation for canning which

brought patent 2,564,487 to Perry W. Mader and Gerstle I. Mader, Robertsdale, Ala. Rights are assigned to Food Research Institute, Inc., of Alabama.

Fresh shark meat, these inventors say, is toxic to men and dogs but shark meat is quite wholesome in the dried state or when semi-putrid. It is used in parts of the world as food but only when it has become partly rotten or dried. This new process removes from fresh shark meat the chemicals which cause the toxicity. The meat, still fresh, can then be preserved in cans and eaten with safety at any time.

The trimmed meat is boiled in an open kettle. A sudden release of a large amount of carbon dioxide in the boiling water is provided. Then the pot is allowed to boil over for a limited time. The harmful ingredients in the shark meat are carried out in the overboiling.

Sunlamp Phosphor

➤ A SUNLAMP phosphor to use to coat the inside of the tube of a fluorescent lamp was awarded patent 2,563,901, issued to Rudolph Nagy and Robert W. Wollentin, Bloomfield, N.J. Westinghouse Electric Corporation, East Pittsburgh, Pa., has acquired the patent rights.

The particular object of the invention is to produce an efficient phosphor whose peak of emission is near that of the erythemal spectrum, the portion that emits the radiation required in a sunlamp. It gives only a small output of visible radiations. In the preparation of the phosphor, there is produced a solid solution of magnesium and calcium ortho phosphates activated with thallium.

Cheaper Germanium Crystal

➤ A FORWARD step in replacing vacuum tubes in radio receivers with germanium rectifiers and amplifiers is promised with cheaper germanium crystals produced by a process on which the government issued a patent.

The process uses a less pure germanium metal as a starting material and thereby greatly reduces the cost of manufacturing. The inventor claims the process results in a germanium crystal with improved electrical characteristics.

Germanium is a rather rare metal that has the property of being a semi-conductor of electricity. That is, it will pass electric current in only one direction. For this reason it can be used to rectify a current, that is convert alternating current to direct current. It can also be used as an electric amplifier. It is already coming into use to replace vacuum tubes in radio receivers and other instruments where simple amplifying is required.

The new crystals are made by reducing germanium dioxide in powder form in an atmosphere of hydrogen at a temperature of 700 degrees Centigrade. Then one percent of metallic tin is added, and one-tenth of one percent of additional germanium dioxide. The mixture is heated at a temperature of about 1,000 degrees.

Inventor is Salvatore F. Amico, East Boston, Mass. He received patent 2,565,338. Rights are assigned to Sylvania Electric Products, Inc., Salem, Mass.

Ordinary talc, or soapstone, is largely magnesium silicate.

Cleaning Agents Win On Their Own Merits

Detergents From Petroleum

➤ Recent advances in petroleum refining point the way to new and better detergents for home and industrial uses, William K. Griesinger, director of research and development of the Chemical Products Division, Atlantic Refining Company, Philadelphia, told the American Chemical Society.

Detergents, the soap-like materials made through chemistry from fats and oils, have skyrocketed into scores of uses in the last twenty years, Mr. Griesinger told the Division of Petroleum Chemistry in a paper of which J. A. Nevison was co-author.

The compounds clean dishes and clothes and are used in hair shampoos, to clean woodwork and wash cars, to keep oil clean in automobiles, to prevent rust, clean metals, wash wool, and in many other applications. About half the detergents are based on oils from the petroleum industry.

Now, the Philadelphia chemists said, improved petroleum refining techniques may make possible the synthesis of even better detergent products from petroleum hydrocarbons. And application researchers promise to expand further the growing markets for products of this type.

Twenty years ago when the first synthetic detergents were introduced in this country, the American housewife relied almost entirely upon soaps made from animal fats for use in cleaning jobs; today about half of the packaged cleaners on the grocers' shelves contain soap-like materials made through chemistry from fats and oils—and about half of these synthetic products are in turn derived from petroleum hydrocarbons, the report stated.

Growth of our economy has caused a variety of impending domestic problems. Among these has been that of the American housewife in keeping family and household clean through periods of belching factory smoke stacks, soap shortages, and even periods of limited water supply. These problems have been largely anticipated and eased by the cooperative efforts of the detergent and petroleum chemists who have synthesized outstanding soap-like materials from readily available petroleum hydrocarbons.

These synthetic detergents have succeeded beyond serving as a substitute for ordinary soap (made from animal fats) and have won a permanent place in household cleaning products on their own merits. Their outstanding pleasing characteristics in household uses are largely illustrated by their good performance in all types of water, soft municipal waters or hard mineral waters; their complete draining and ease of rinsing from clothes and dishes, thus requiring a minimum of water to obtain clean, sparkling results; and their availability in neutral, mild forms which

can be used in cleaning wool, silk and other fine fabrics without damage to the goods.

Where the active or "synthetic detergent" component of cleaning compositions is tailor made, it is capable of production in many diversified forms, each form being designed for a specific end use. These active components are further modified or "built" for consumer needs by blending with other materials which contribute to their performance in specified cleaning jobs. Hence, today there are literally dozens of different active or synthetic detergents available for formulating into cleaning materials from fifty or more different manufacturers in this country. These products are available in varieties of different forms—as dry flakes; free-flowing, dustless beads; pastes and concentrated slurries; and clear fluids which may contain 20 to 100 per cent active material.

The above bulk products are then further compounded and packaged for use or retail sales; the number of concerns engaged in this business runs into the thousands and includes manufacturers of detergents, compounders and packaging companies, distributors, and in many instances consumers. Results of a substantial portion of this busines activity may be seen on display in grocery stores across the country. The products of interest to the American housewife include products for laundry work, dishwashing, rug shampooing, cleaning woodwork, car washing, toilet articles, hair shampoos, and so forth.

Large volumes of detergent-type chemicals are used in the automotive field, where their inclusion in lubricating oils limits corrosion and sludge deposition in engines, thus effecting improved performance and longer life.

Natural Gas Liquids for Motor Fuel

➤ ONE GALLON of motor fuel can be added to every ten now available for America's automobiles by squeezing the liquid fuel out of the great outpouring of natural gas.

Dr. B. R. Carney of the Warren Petroleum Corporation, Tulsa, told the American Chemical Society that nearly 150,000,000 barrels of liquids could be condensed out of available natural gas by methods now developed.

These natural gas liquids, propane and butane, can be used directly as motor fuel for tractors, trucks and buses and they can be blended in conventional gasoline.

At present the natural gas liquids are used as raw material for synthetic fibers, electrical insulation, refrigerants, alcohols, synthetic rubber, but they could be most valuable economically by burning them in engines for vehicles.

Vitamin B-12 is important as a supplement to the feed of young pigs and chickens; it enables them to grow to market weight more rapidly and on less grain.

Cotton Fibers Studied
To Determine Luster

Spirals Explain Cotton Sheen

➤A KEY to making cotton more lustrous, and therefore making cotton goods more attractive to customers, was reported to the American Chemical Society by Lyman Fourt and Arnold M. Sookne of the Harris Research Laboratories, Washington.

The key is the direction of inner spirals of the molecules of cellulose in the cotton fiber itself, the Washington chemists said. Cotton is more lustrous when these spiral patterns are laid down closer in the direction of the long cotton fiber itself. The spiral pattern makes an angle with the general direction of the fiber. The angle can be measured by X-rays, and luster is higher when the angle is smaller. Treatments that can decrease the angle, therefore, should produce cotton goods with a higher luster.

In cotton goods, luster of shine or bright clear color is usually a good sign of high quality and attracts consumers. For this reason, the United States Department of Agriculture has set up a research project at the Harris laboratories, under the Research and Marketing Act, on "the improvement of luster of cotton."

The basic chemical units of cotton, the molecules of cellulose, are themselves long and thread-like, the report explains. As the cotton fiber is formed in the boll, the thread-like molecules of cellulose are laid down in a spiral pattern which makes an angle with the general direction of the fiber. This angle can be measured by X-ray methods. It is found that the closer the spirals of cellulose molecules come to the direction of the fiber as a whole, the higher is the luster of the fiber.

There is an analogy between the aged-old living processes which arrange the molecular structure of cotton, and some of the manufacturing processes used to make one of the new man-made fibers, nylon. In the production of nylon, the thread is stretched or drawn out to several hundred per cent of its original length, which brings the invisible thread-like molecules inside the visible nylon thread more nearly in line with the general direction of the fiber. Just as with cotton, this produces an increase in luster.

The greater straightness of the spirals inside the more lustrous cottons is also paralleled on a larger scale by the relations between twist in yarns and luster. An old practice in the hosiery trade, where dullness is desired, is to increase the twist. This increases the angle between the individual fibers and the general direction of the yarn. In making yarn for cotton goods, mechanical means of securing increased luster include decreasing the twist and plying two yarns together with opposite twist, thus bringing the individual fibers more nearly in line.

The length of the fibers has always been one of the chief considerations in selecting cotton for the highest qual-

ity goods and for the highest luster. The differences between the different varieties of cotton as grown in the fields are not only differences of fiber length and size, but also of the spiral angle. The strength of the cotton is known to be related to this spiral angle, and is more readily measured, so that the practical cotton man can use fiber strength as an additional indication of the kind of cotton to use to obtain high luster.

How Protein is Utilized in Food

➤ RADIOACTIVE chemicals are helping scientists learn more about how dairy calves utilize the protein in their feed.

Digestion and absorption of casein, the chief protein of milk, starts very quickly, G. P. Lofgreen of the Univeristy of California's animal husbandry division reports from such studies.

Casein digestion continues for 24 hours, in contrast to the short time required for fat absorption. And phosphate exchange goes on at a high rate in the omasun, one of the three stomach compartments of the calf and other ruminants.

Stock "Bal", Pharmacists Urged

➤ STOCK BAL as part of your public emergency service, the nation's pharmacists are urged by their national organization, the American Pharmaceutical Association.

BAL, short name for British Anti-Lewisite, is at present the only known specific antidote for poisoning by heavy metals such as arsenic, mercury and gold. It was developed in England during the early days of World War II to counteract the effect of Lewisite, poison gas containing arsenic. Kept hush-hush during the war, it was released for civilian use at the end of the war.

The manufacturers of BAL at times have received frantic telephone calls from all over the country asking that a supply of the chemical be flown immediately to the bedside of a patient who has swallowed bichloride of mercury or a child who has eaten rat poison containing arsenic. It has not always arrived in time, the pharmaceutical association reports.

Every hospital and retail pharmacy should have at least a 10-vial package on hand at all times with complete directions for use, Dr. James H. Lade of the New York State Health Department urges. He has recently had a supply of BAL stocked in 128 laboratory supply stations throughout the state for free distribution to all physicians in case of arsenic and mercury poisoning. But, he points out, physicians would not normally turn to a health department laboratory for such a drug.

Many lives would be saved each year, he believes, if the physician could get the drug at pharmacies where he normally would go for a poison antidote.

Book Concentrates

➤ *Biochemistry and Physiology of Protozoa* Volume I — Andre Lwoff, Ed. (*Academic Press,* 434 p., $8.80. Bringing together contributions to this neglected field.

➤ *An Evaluation of the Hardening Power of Quenching Media for Steel* —Earl J. Eckel, Ross M. Mayfield, Glen W. Wensch and Frank A. Rough (*University of Illinois,* 131 p., illus., paper, $1.50.) Although the quenching of steel was first mentioned in the Odyssey, 900 B.C., the relative value of different quenchants has been largely a matter of opinion.

➤ *Herbert H. Dow:* Pioneer in Creative Chemistry — Murray Campbell and Harrison Hatton (*Appleton,* 168 p., illus., $3.50.) The life of the founder of the Dow Chemical Company and one of the creators of modern chemical industry.

➤ *Mineralogy:* An Introduction to the Study of Minerals and Crystals—Edward Henry Kraus, Walter Fred Hunt and Lewis Stephen Ramsdell (*McGraw-Hill,* 4th ed., 664 p., illus., $7.50.) A text for beginning students.

➤ *The Restless Universe*—Max Born (*Dover,* 2nd ed., 315 p., illus., $3.95.) Scientists and students will welcome this new revised edition of a book that has been out of print for several years. A novelty is a sequence of diagrams by means of which you can see molecules in action by flipping the pages. Translation by Winifred M. Deans.

➤ *Food and You*—Edmund Siguard Nasset (*Thomas,* 92 p., $3.00.) What the author describes as a "modest essay on a most important subject."

➤ *200 Miles Up:* The Conquest of the Upper Air—J. Gordon Vaeth (*Ronald,,* 207 p., illus., $4.50.) Telling about the highest flights yet made and the information they brought back about the atmospheric sea above.

➤ *Conference on the Sun in the Service of Man*—Harlow Shapley, Chairman (*American Academy of Arts and Sciences,* 145 p., illus., paper, $2.50.) Papers read at a conference which brought together researchers at Harvard and MIT as well as others interested in solar problems.

➤ *The Drug Plants of Illinois*—Leo R. Tehon (*Natural History Survey,* 135 p.; illus., paper.) Single copies free upon request to publisher, 184 Natural Resources Building, Urbana, Ill. How to collect, dry and market common herbs with medicinal value.

➤ *Time's Arrow and Evolution*—Harold F. Blum (*Princeton University Press,* 222 p., illus., $4.00.) The author, a biologist, points to a part played by the Second Law of Thermodynamics in the course of evolution.

➤ *The Formation of Mineral Deposits* —Alan M. Bateman (*Wiley,* 371 p., illus. $5.50.) Why minerals are where they are and where others may be found.

➤ *The History of Science:* Origins and Results of the Scientific Revolution—Sir Lawrence Bragg and others (*The Free Press,* 184 p., illus., $2.50.) Radio talks by noted scientists. Not intended as a comprehensive history, this little book presents rather significant samples beginning with Democritus in 460 B.C.

➤ *Modern Plastics Encyclopedia and Engineer's Handbook: Including Special Defense Section* (*Plastics Catalogue Corporation,* 636 p. illus., paper, \$2.00.) Reference work for dealers, industrial chemists and others interested in this comparatively new field.

➤ *Nutrition for Health*—Holger Frederick Kilander (*McGraw-Hill,* 415 p., illus., \$3.00.) A high school text intended to teach young people how to select their foods and how to prepare and care for them.

➤ *Plants in the City*—Herman and Nina Schneider (*John Day,* 96 p., illus., \$2.50. Telling boys and girls, through simple experiments, how plants can grow even in the city and without soil.

➤ *Radiocarbon Dating* — Frederick Johnson, Ed. (*Society for American Archaeology,* 65 p., paper, \$1.50.) Including a timetable of radio-carbon dates for various important samples of ancient remains and discussions by various experts of their significance.

➤ *Read the Label on Foods, Drugs, Devices, Cosmetics*—Food and Drug Administration (*Govt. Printing Office,* 40 p., illus., paper, 15 cents.) Telling how to read the label to get your money's worth and guard your family's health.

➤ *Fundamentals of Semimicro Qualitative Analysis*—Erwin B. Kelsey and Harold G. Dietrich (*Macmillan,* rev. ed., 328 p., illus., \$4.00.) Designed to provide correlation of theory with actual laboratory practice.

➤ *Activity Period in Public High Schools*—Ellsworth Tompkins (*Govt. Printing Office,* 17 p., paper, 15 cents.) Information and statistics on how high schools organize the time devoted to the activity period. Bulletin No. 19 of the Office of Education.

➤ *Consumer's Stake in Textile Processing*—Jules Labarthe, Jr. (*Mellon Institute,* 3 p., illus., paper.) Free on request to publisher, 4400 Fifth Avenue, Pittsburgh 13, Pa. Discussing the demands made by the consumer on textile finishes.

➤ *Fundamentals of Electronics*—F. H. Mitchell (*Addison-Wesley,* 242 p., illus., \$4.50.) As instrumentation grows in importance, electronics penetrates more and more into other branches of science. This text lays a foundation for electronics students and shows others how electronics may be applied in other branches.

➤ *How To Study, How To Solve, Arithmetic Through Calculus*—H. M. Dadourian (*Addison-Wesley,* 121 p., illus., paper, 60 cents.) Intended to overcome the fear and mystification associated with advanced mathematics.

➤ *The Human Side of Industry* (*Industrial Hygiene Foundation,* 102 p., illus., paper, \$2.00.) The transactions of the 15th annual meeting of the Foundation.

➤ *An Introduction to Acoustics*—Robert H. Randall (*Addison-Wesley,* 340 p., illus., \$6.00.) A textbook for the student who has completed a general college course in physics. Includes chapters on musical instruments.

➤ *Iodine: Its Properties and Technical Applications* (*Chilean Iodine Educational Bureau,* 74 p., paper.) Free upon request to publisher, 120 Broadway, New York 5, N. Y. Describing important uses of iodine in organic chemistry and industry.

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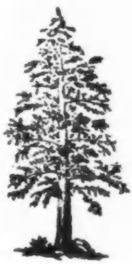

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